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Evaluating changes in driver behaviour: A risk profiling approach

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ABSTRACT

New road safety strategies continue to be devised by researchers and policy makers with pay-as-you-drive (PAYD) schemes gaining increasing attention. However, empirically measuring the effectiveness of these strategies is challenging due to the influence of the road environment and other factors external to the driver. The analysis presented here applies Temporal and Spatial Identifiers to control for the road environment and Driver Behaviour Profiles to provide a common measure of driving behaviour based on the risk of a casualty crash for assessing the effectiveness of a PAYD scheme on reducing driving risks. The results show that in many cases personalised feedback alone is sufficient to induce significant changes, but the largest reductions in risk are observed when drivers are also awarded a financial incentive to change behaviour. Importantly, the more frequent the exposure to the speeding information, the greater the magnitude of the change. However, the changes are disproportionately associated with those that were already safer drivers in the baseline period suggesting that some drivers may be predisposed to changing their behaviour. These results suggest that it would be beneficial to provide real-time or daily feedback on speeding behaviour in conjunction with a financial reward scheme, potentially as a component of insurance premiums.

1. Introduction

New road safety strategies continue to be developed by researchers and policy makers. Of these, pay-as-you-drive (PAYD) reward/insurance schemes have gained increasing attention (see Elvik, 2014). PAYD provides financial incentives to motorists based on their driving behaviour to encourage reductions in speeding and other risky driving, or penalties for poor behaviour. However, empirically measuring the effectiveness of these strategies is a challenging task because behaviour is frequently influenced by the road environment, and road crashes – arguably the best indicator of risky driving – are rare even for the worst drivers. Naturalistic driving data–data collected using sensors during day-to-day driving – tend to be an intrinsic component in PAYD studies. However, direct comparisons are difficult due to the influence of external factors and the need to isolate the financial, education and other components of these schemes.

This paper reports on an examination of the effect on risky driving behaviour – speeding, acceleration and braking specifically – of increasing awareness of speeding behaviour and a financial reward as part of a PAYD study conducted on 106 drivers in Sydney, Australia (Greaves et al., 2010). The overall study consisted of several components including a financial reward for reducing speeding and, implicitly in the design of the study, individualised and daily feedback on the frequency of speeding behaviour. The analysis presented here applies Temporal and Spatial Identifiers (TSI) (Ellison et al., 2013) to control for the road environment and Driver Behaviour Profiles (DBP) (Ellison, 2014) to provide a common measure of driving behaviour based on the risk of a casualty crash for the purposes of comparing the change in behaviour between the before and after phases.

It can be argued that without controlling for the effect of spatiotemporal characteristics and incorporating different magnitudes of behaviour, an analysis of before-and-after data may be explaining changes in these factors rather than changes that occur as a consequence of the intervention. For example, Toledo et al. (2008) developed a method of assessing driver behaviour using naturalistic driving data which could then be used as both feedback for the driver and in before-and-after measurements. However, despite including 20 manoeuvres it does not control for changes in where and when driving occurred. In contrast, this paper controls for these factors and thereby isolates the influence of the driver. In so doing, it then becomes possible to assess the individual merits of increasing awareness and imposing a financial incentive to change behaviour. Furthermore, by using a measure of risk, this paper

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provides an indication as to the impact of PAYD schemes on the risks of involvement in a casualty crash itself as opposed to simply a measure of behaviour.

Background information and literature review is presented first, with a focus on feedback and financial incentives. This is followed by a description of the study design and data collection process. The methodology and data processing techniques applied are then outlined. Modelling results are then presented. The paper concludes with discussion and conclusions.

2. Background and literature review

Changing driver behaviour can be approached in a number of ways. Education campaigns are used to educate drivers about the consequences associated with particular behaviours on the premise that increased knowledge, and in some cases greater fear or shame of the consequences, will result in a beneficial change in behaviour. In other cases, drivers already know (or are assumed to know) the dangers associated with risky behaviours and, therefore, methods are used to make drivers aware of their own behaviour. This can be done in real time through an in-car device or retrospectively. There are a number of methods for providing this information including dynamic speed display signs (Gehlert et al., 2012; Roberts and Smaglik, 2012), passive in-vehicle Intelligent Speed Adaptation (ISA) devices fitted to vehicles, through smart-phone apps used within the vehicle that determine the actual speed and speed limit and provide audible and visual warnings when necessary, using active ISA[1] that physically pushes back on the accelerator when the driver is speeding (Várhelyi et al., 2004), or post-travel through a web-based system. These methods do not educate drivers on the risks they are taking but do increase awareness of how they are driving. The premise here is that at least some speeding behaviour is inadvertent (Corbett, 2001) and therefore mechanisms for making drivers aware of the extent to which they speed may encourage greater care to be taken.

Financial incentives (and disincentives) can also be used to encourage behaviour change. This method rewards drivers for not engaging in risky driving behaviour, such as speeding, or penalises them each time they engage in a specific behaviour through a monetary mechanism. Speeding fines are a crude example of a financial disincentive but more sophisticated programmes such as PAYD are becoming more common. These schemes provide more refined and consistent financial incentives to improve behaviour compared to fines.

2.1. Real-time and retrospective feedback

Intelligent Speed Adaptation (ISA) technology alerts drivers to their speeding behaviour in real time using audible tones, visual warnings on a screen and, in some cases, pushback on the throttle itself. The results of ISA trials allude to the possibility that real-time feedback may be sufficient to encourage a change in behaviour. For example, drivers in an ISA trial conducted in NSW, Australia revealed that being advised they were speeding (using an audible warning) increased their awareness of their frequency of speeding behaviour and made them aware they were speeding when they inadvertently drove in excess of the posted speed limit. Overall, 89% of vehicles recorded lower proportions of time speeding with an ISA device installed than before it was installed (NSW Centre for Road Safety, 2010). These results are consistent with other ISA trials (for example Jamson, 2006) although a study of young drivers has found that monitoring and alerts by themselves are not sufficient to change risky driving behaviour in the long term (Farmer et al., 2010). A small-scale study with 37 participants, incorporating a real-time feedback and reward scheme[2] for participants to reduce speeding, found that speeding was reduced during the feedback phase. After the completion of the feedback phase, drivers' speeding increased but remained lower than the baseline phase for higher speed limits[3]. The authors note that the speed limit was a significant factor in explaining behaviour (Merrikhpour et al., 2012; Merrikhpour, 2013). This suggests that a proportion of the benefits from feedback schemes are retained after feedback are no longer provided. In addition, the extent to which changes occur vary substantially by spatial characteristics and this should be taken into account when using these strategies. Bolderdijk et al. (2011) provided feedback to participants using a personalised website as part of a PAYD study and observed reductions in speeding during the intervention. The authors do not distinguish between the effects of the financial and awareness components of the study but note that few participants visited the website. This may partially explain why after the end of the intervention phase speeding increased relative to the baseline phase indicating that a financial incentive alone may not induce long term changes. It would appear that merely providing feedback is not sufficient and there needs to be either a compulsion or an incentive for drivers to access the feedback. This could simply be a matter of asking drivers to confirm whether they did or did not drive each day as a condition of receiving the financial incentive.

The effectiveness of feedback on other behaviours has also been studied. For instance, Donmez et al. (2008) used driving simulators to test the effect on braking behaviour of real-time and retrospective feedback presented at the end of each trip. The authors found that the results were similar for real-time feedback combined with retrospective feedback and retrospective feedback alone with both showing significant improvement compared to drivers that received no feedback. A learning effect was also observed whereby braking behaviour (for both feedback types) improved over the four simulated driving sessions. Trials in commercial vehicles resulted in similar improvements and significant reductions in crash rates (38%) after the feedback was introduced compared to the control group which received no feedback (19% reduction) (Toledo et al., 2008).

While most studies have found feedback to be effective in changing behaviour, there is some variation between different groups of drivers. A study on the effect of feedback on teenage drivers (Simons-Morton et al., 2013) found that it was necessary for parents to be informed of the behaviour. Feedback only seen by the drivers themselves was not effective at reducing risky driving behaviour, heavy braking and sharp turns in particular. These results are not universal with other studies finding young drivers to benefit from feedback (for example, Musicant and Lampel, 2010). The difference in results shares similarities with research on the influence of parents and peers on young drivers' behaviour. The research suggests that children's driving style is strongly correlated with that of their parents (Bianchi and Summala, 2004; Taubman - Ben-Ari et al., 2005; Prato et al., 2009) but the evidence also shows a relationship with the behaviour (and perceptions) of peers (Fleiter et al., 2006; Simons-Morton et al., 2012). Post-trip feedback with parental involvement may be related to the way in which the opinions and behaviour of passengers and other road users is prioritised over family members that are not present (Haglund and Åberg, 2000). In effect, the feedback mechanism may be creating a situation in which the parent becomes a 'phantom' passenger by virtue of being able to view the driver's behaviour. It is possible that

[1] Active ISA is also known as active accelerator pedal (AAP).

[2] The reward scheme consisted of points accumulated for compliance which could be redeemed for gift cards at the completion of the study.

[3] The authors defined higher speed limits as 70, 80, 90 and 100 km/h speed limits.